Adult Chinook Escapement Assessment Conducted on the Cowichan River During 1999

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LIST OF TABLES

Tables		Page
1.	Daily counts at the enumeration fence site, Cowichan River, 1999	15
2.	Daily counts by time interval at the enumeration fence site, 1999	17
3.	Visual survey data collected for the Cowichan River by Fishery Officers stationed in the Duncan Subdistrict	18
4.	Native food fish catch estimates for the Cowichan River	22
5.	Summary of chinook broodstock collected by the Cowichan hatchery, 1999	23
6.	Adult and jack chinook used for hatchery broodstock, Cowichan River	24
7.	Summary of chinook broodstock age data, 1999	25
8.	Length-frequency of chinook carcasses sampled on the spawning grounds, Cowichan River, 1999	26
9.	Summary of chinook age data collected on the spawning grounds, 1999	28
10.	Length-frequency of chinook broodstock collected by the Cowichan River hatchery, 1999	29
11.	Coded-wire tag code data from chinook sampled on the spawning grounds, 1999	31
12.	Cowichan hatchery chinook release data, 1979-99	32

LIST OF TABLES (cont'd)

Tables Page

13. Cowichan River daily discharge measured in cu. m/sec for 1999..... 35

14. Summary of chinook carcass mark-recapture data from the Cowichan River, 1999..... 36

15. Petersen chinook escapement estimates by sex, Cowichan River, 1999..... 37

16. Incidence of tagged adult chinook carcasses recovered on the spawning grounds, by recovery period, in the Cowichan River, 1999..... 38

17. Proportion of the tag application sample recovered on the spawning grounds, by period, Cowichan River, 1999... 39

18. Summary statistics for Kolmogorov-Smirnov length-frequency comparison for tagged and recaptured chinook carcasses, Cowichan River, 1999..... 40

19. Sex composition of application and recovery samples of Cowichan River chinook, 1999..... 42

20. Total adult chinook returns to the Cowichan River, 1975-1999..... 43

LIST OF FIGURES

Figure		Page
1.	Cowichan River survey areas	45
2.	River management zones for Native food fishery	47
3.	Daily fence count of adult and jack chinook, water depth and temperature, 1999	49
4.	Adult chinook catch data from First Nations food fishery, Cowichan River, 1971-1999	51
5.	Cowichan River discharge (cu m/sec) in 1999 compared with historical trends	53
6.	Adult chinook escapement estimates for the Cowichan River, 1953-1999	55
7.	Hatchery chinook released into the Cowichan River as fry (3 gm) and as pre-smolts (6 gm)	57
8.	Natural and enchanced contribution to escapement, Cowichan River, 1982-1999	59

ABSTRACT

Nagtegaal, D. A. and E. W. Carter. 2000. Adult chinook escapement assessment conducted on the Cowichan River during 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2544: 59 p.

In 1999, the Stock Assessment Division, Pacific Biological Station, conducted a study of chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. This indepth adult escapement assessment project has been in place since 1988. Major components of this ongoing study include: i) enumeration of spawners and total return, ii) estimation of Native food fish catch, iii) recording hatchery broodstock removals, iv) biological sampling and coded-wire tag (CWT) recovery data collection. A carcass mark-recapture study was conducted to augment the fence count. Total return of adult chinook to the Cowichan River was estimated to be 6,392 in 2000. The number of natural spawners was estimated to be 4,500. Carcass mark-recapture escapement estimate of upper river spawners was determined to be 3,440 (95% CL; 2,908 - 3,972).

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RÉSUMÉ

Nagtegaal, D. A. and E. W. Carter. 2000. Adult chinook escapement assessment conducted on the Cowichan River during 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2544: 59 p.

En 1999, la Direction des sciences biologiques de la Station biologique du Pacifique a entamé une étude sur la productivité du saumon quinnat (Oncorhyncus tshawytscha) dans la rivière Cowichan. Cette étude, qui est toujours en cours, porte principalement sur : i) le recensement des reproducteurs ; ii) le volume de la pêche autochtone de subsistance ; iii) le recensement des spécimens de recrues issus d'écloserie ; iv) l'échantillonnage biologique et l'examen des micromarques magnétisées codées (MMC). Soulignons qu'une étude consistant à étiqueter les carcasses de reproducteurs pour qu'on les remette à l'eau afin de comparer le nombre de carcasses de reproducteurs étiquetées et non étiquetées a permis d'étayer les résultats obtenus aux barrières de comptage. Pour l'année 2000, l'effectif de remonte total du saumon quinnat adulte - écloseries et frayères naturelles confondues - dans la rivière Cowichan se chiffrait à 4 500, le nombre de reproducteurs issus de frayères naturelles étant estimé à 6 392. Enfin, les auteurs décrivent un plan de gestion des eaux destiné à faciliter la remonte du quinnat.

INTRODUCTION

Considerable interest has been focused towards the chinook salmon (*Oncorhynchus tshawytscha*) stocks in the southern portion of the Strait of Georgia over the past several years due to the perceived decline in these stocks and their importance to the local fisheries (Farlinger et al. 1990). The Stock Assessment Division, Pacific Biological Station, initiated a study of chinook productivity to assess rebuilding strategies and to evaluate the effects of harvest management policies for these stocks. In the fall of 1988, a study was implemented on the Cowichan River chinook stock with additional information collected from the Squamish and Nanaimo River chinook stocks. These three stocks were identified as escapement indicators to represent the status of Lower Georgia Strait chinook stocks.

Hatchery production of chinook on the Cowichan River began in 1980 (Cross et al.,1991). Chinook fry releases have increased from 64,681 in 1980, to 2,543,136 in 1999. Marked releases also began in 1980 and in 1999 approximately 15% of the total number of chinook released were coded-wire tagged.

The objectives of this study include: i) to quantitatively determine the optimum spawning requirement for chinook salmon in the Cowichan River (this involved investigations of the determinants of juvenile production, interactions between hatchery and wild chinook, and estimation of the spawning escapement and catch attributed to the hatchery and wild components of the total run), and ii) to develop guidelines for establishing escapement targets for other B.C. chinook stocks (Nagtegaal et al.,1994a).

The purpose of this report is to present the results of the adult escapement enumeration component of the chinook productivity study conducted on the Cowichan River during the fall of 1999.

METHODS

Components of escapement enumeration include: i) enumeration of chinook salmon at the counting fence; ii) estimation/biological sampling of Native food fishery catch; iii) recording of hatchery broodstock removals; iv) collection of biological data and sampling of coded-wire tag (CWT) recoveries; and v) carcass mark-recapture studies for both adult and jack chinook.

A detailed description of the methodology used to collect the above information was presented in Nagtegaal et al. (1994b). Some changes were made in 1999 and are described below. The counting fence was placed in the same location as in previous years (Fig. 1).

ENUMERATION FENCE

A resistance board weir was installed with a counting raceway (adjustable flashboard) and trap box adjacent to the counting tower equipped with floodlights. Counts were continuously recorded for the duration of the operation by 15 minute intervals for adult and jack chinook, adult and jack coho, and chum. If identification was in doubt those fish were recorded as unknown. Water depth, temperature, and clarity, and weather conditions were recorded three times per day. On a daily basis the integrity of the fence was checked and cleaned of leaves and other debris. Records of broodstock collected at the fence by the hatchery staff were also kept.

SWIM SURVEYS

Swim surveys were conducted, in conjunction with Cowichan Tribes Aboriginal Fisheries Management (CTAF), to estimate the spawning population of chinook. The swims were made in the upper section of the river only (Fig. 1) and extrapolated to the total system. Each survey was conducted by three experienced swimmers and one person in a canoe who recorded the data. Each swimmer (one in the middle and one on each side of the river) counted the fish seen within their range of visibility. The three swimmers attempted to keep abreast as they approached each pool while the person in the canoe lagged behind within hailing distance. Counts were recorded by pool/riffle and then compiled by river section. When possible the same swim team was used for each survey to maintain consistency in counting procedures. Swim counts were expanded by a factor of 3.4, based on historical distribution of spawners, to derive an escapement estimate (Nagtegaal et al. 1994a). This expansion factor was consistently applied to swim counts with no adjustments made for run timing or the changes in the distribution of chinook in the river. A final escapement estimate was then determined in consultation with Fisheries and Oceans Canada Fishery Officers and based on other anecdotal information.

It was intended that the swim survey estimates remain independent of the fence count. Even though no fence count information was passed on to the swim teams during the season, general trends in escapement numbers were known.

NATIVE FOOD FISHERY

In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management (CTAF) program to monitor the fishery more closely and to better estimate the Native food fish catch (Paige 1992, 1997). This approach involved recording catch and effort by management zone within the Native fishing boundaries (Fig.2). A crew of four observers patrolled the fishery on a daily basis and interviewed fishermen for numbers caught by area and total time spent fishing. In this way, weekly estimates of catch per unit effort (CPUE) were obtained. CPUE was adjusted for daily changes in fishing effort and differences in effort among fishing zones. These data were then extrapolated over time and area to estimate total catch by week and summed over all weeks to estimate the total 1999 catch.

$$CATCH \equiv \sum_{n}^{w=1} CPUE_{w} \times EFFORT_{d}$$

where w refers to the time interval for catch (week), and d refers to the time interval for effort (day). No confidence limits were calculated (Paige 1997).

For some years since 1988, an observer was employed to independently collect catch and biological data from the in-river chinook spear fishery. Due to budget contraints no independent biosampling of the fishery was conducted in 1999.

BIOLOGICAL DATA

Biological data for chinook were collected from two sources: i) hatchery broodstock samples; and ii) carcass mark/recapture (spawning grounds). Hatchery staff randomly collected biological data from approximately 25% of the chinook broodstock, recorded the incidence of coded-wire tagged (CWT) fish, and selectively sampled all additional CWT fish. On the spawning grounds chinook were sampled for post-orbital hypural (POH) length, sex, scale, spawning condition and the presence/absence of an adipose clip. All coded-wire tagged fish recovered were biosampled, the head removed and frozen for further analysis.

MARK-RECAPTURE

A multiple mark-recapture program involving the tagging and subsequent recovery of chinook jack and adult carcasses was conducted on the spawning grounds (Sykes and Botsford 1986). All chinook carcasses were individually tagged with a Ketchum[1] aluminum sheep ear tag on the

[1]Ketchum Manufacturing Ltd., Ottawa, Canada.

left operculum and immediately released in the same area as captured. Location of capture and release, tag number, spawning condition, length, sex, and adipose clip information were recorded for each carcass recovered. Tag numbers and location of previously marked carcasses were recorded and the carcass returned to the river in the same site as captured.

Two or three man crews in inflatable boats daily surveyed the upper section of the river (Fig. 1) and collected all available chinook carcasses. This section of the river above Skutz Falls represents the area where the majority of chinook spawning typically occurs. On two occasions, one of the crews collected carcasses from the middle section of the river (Fig. 1). A 4.2 m pole with a gaff hook attached to the end was used to recover carcasses. Some carcasses were likely missed if they ended up in pools too deep for retrieval.

POPULATION ESTIMATE

Adult chinook salmon escapement estimates were generated from the carcass mark-recapture data using the Petersen model (Chapman modification) stratified by sex and river section (Ricker 1975). As in past years, it was necessary to stratify the data in order to minimize the effects of differential tagging and tag recovery between sexes and river sections. This study follows the estimation procedure as outlined in previous reports (Nagtegaal et al. 1994a, 1994b, 1994c).

RESULTS

ENUMERATION FENCE

In 1999, the counting fence was operated from Aug. 27 through to Oct. 30. Due to high water conditions at the end of the study the fence operation was terminated. Daily counts at the enumeration fence are contained in Table 1, and compared with water depth and temperature recorded at the fence (Fig. 3). Total counts recorded during this period were: 3,824 adult chinook; 1,291 jack chinook; 2,353 adult coho; 670 jack coho; 2,184 chum and 59 unidentified fish. During the last days of operation, the combination of heavy rain, increasing flow and muddy water made identification difficult. Only a few fish were observed passing over the submersed fence prior to removal.

In past years, especially during the early part of the season, more jack chinook have often been observed to enter the river than adult chinook. The numbers of jack chinook were particularly low and the ratio of jack to adult chinook was the lowest since the project began in 1988. Daily counts were summarized by one hour intervals (Table 2) and we note that peak movement of adult and jack chinook occurred between

0700 and 0900 and again between 2200 and 2400. Approximately 51% of adults and 28% of jacks migrated past the fence during daylight hours.

During several shifts throughout the migration period an independent count was made at the enumeration fence to determine the accuracy of the counting procedure and species identification. On several occasions, fish were visually identified by an observer in the counting tower and then captured in the fish trap and identified by a second observer. Of the 150 fish examined, three fish (2%) were incorrectly identified. Errors were made in mis-identification of jack or adult fish.

SWIM SURVEYS

A summary of visual surveys conducted by Fishery Officers and Cowichan Tribes Aboriginal Fisheries Management from 1981-1999 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. Swims in 1999 were conducted in the upper section of the river (Birdhouse to Three Firs pool; Fig. 1) on Sept. 10 and Oct. 13. The 1999 escapement of adult chinook was determined to be about 5,000 based on the upper river swim counts. The two swim surveys were conducted under good conditions (low water and clear visibility).

NATIVE FOOD FISHERY

Estimates of the Native food fish catch of chinook since 1981 are listed in Table 4. The 1999 catch estimate of 233 adults and 89 jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group (Fig. 2). According to their observations, the adult chinook spear fishery was more successful than the catch estimates indicate, (Fig. 4) since low water conditions remained during the fishing season. Although it was very difficult to assess the quality of the data collected, the catch estimate was considered to be low. According to Aboriginal Fisheries Guardians the number of adult chinook taken in the spear fishery was likely 600-800 fish.

HATCHERY COMPONENT

In 1999, 1,654 adult chinook were removed from the river by the Cowichan River hatchery staff below the enumeration fence (Table 5). The hatchery staff (D. Millerd, P.O. Box 880, Duncan, B.C., pers. comm.) indicated they had met their target this year (Table 6). Primarily three year old chinook were used for broodstock (Table 7).

BIOLOGICAL DATA

More adult male carcasses than female chinook were sampled on the spawning grounds (Table 8). Since conditions for recapture of carcasses was not optimal throughout the survey with higher flows experienced in November, larger and heavier (female) carcasses were more easily recovered. Most carcasses were recovered on the spawning grounds in the upper section and few from the middle section of the river. Mean size of females sampled was 65.7 cm post orbital hypural (POH) length and for males was 63.9 cm (POH). Adult chinook were primarily comprised of 3 and 4 year old fish (Table 9).

Length-frequency summaries of chinook broodstock collected and sampled at the hatchery are listed in Table 10. The hatchery staff randomly sampled approximately 25% of all broodstock collected and then selectively sampled all remaining adipose-clipped chinook. The adipose mark rate in the random sample was 3.0% for males and 6.3% for females. The mark rate for chinook from hatchery samples was comparable to the mark rate observed on the spawning grounds.

Coded-wire tag recovery information for chinook sampled on the spawning grounds is listed in Table 11. A summary of chinook releases (Kuhn 1988) from the Cowichan hatchery by brood year is listed in Table 12. A cursory look at CWT recoveries on the spawning grounds relative to the total number of fish released indicated that the majority of recoveries were observed from tag groups released in the upper Cowichan (Road Pool) site.

ENVIRONMENTAL INFORMATION

Water flow and temperature measured at the fence site (Table 1) and discharge information recorded at the Water Survey Canada station below the Island highway bridge in Duncan (Table 13), indicated that river conditions during the fall of 1999 were quite typical (Inland Waters Directorate 1999). Compared to the 30 year mean (1960-90), water flow was near mean levels from August to December (Fig. 5) with average rainfall was recorded during this time.

MARK-RECAPTURE

Table 14 contains a summary of the carcass mark-recapture data by tagging period. A total of 601 adult and one jack chinook carcasses were tagged and released in the upper river section and only 5 adults in the middle river section. More than 78% of the adult carcasses were tagged but never recaptured. Smaller and lighter male chinook carcasses are often more readily swept downstream and less likely to be recovered than the heavier female carcasses. Higher water conditions occurred in November and this often causes carcass retrieval to be difficult. This is often the case during the fall and a potential source of bias. This was especially evident in certain areas in the middle river section where cloudy water, due to riverbank erosion, made it particularly difficult to tag and retrieve adult and jack carcasses.

Stratified Petersen

The escapement estimate of adults (excluding jacks) based on carcass mark-recapture data was 3,440 with lower and upper 95% confidence limits of 2,908 and 3,972, respectively (Table 15). This was based on the data from the upper section of the river only since few fish were tagged or recovered in the middle section. It was assumed that greater than 75% of the total escapement spawned in the upper river section.

Potential biases

Some of the typical biases associated with mark-recapture experiments (Ricker 1975) are listed below and were examined in some detail for the carcass mark-recapture data. To minimize bias, fish tagging and recovery occurred concurrently and was stratified by sex and river location.

1. Temporal bias: Temporal bias in the tagging sample was examined by comparing the mark incidence between periods in the recovery sample (Table 16). There were no significant differences in the mark incidence between periods ($P > 0.05$; chi-square; Zar 1984). Mark incidence was somewhat higher towards the end of the survey.

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 17). Significant differences were observed ($P < 0.05$; chi-square). The highest percentage of tags was recovered towards the end of the study. This occurred even though tags were applied at a consistent rate during the study.

2. Location bias: Spatial bias was not examined between the upper and middle river sections due to insufficient sample size in the middle river section. This may have been due to the cloudy water conditions in this section which made carcass tag and recovery

difficult, although a few carcasses were found along the sides of the river. Erosion of some clay banks, which exist in this segment of the river, cause the water to be very cloudy and substantially reduce water visibility. Conditions further deteriorate due to high water.

3. Fish size: Size related bias in the application sample was examined by comparing the continuous POH length frequency distributions of marked and unmarked recoveries from the spawning ground. No significant differences were observed in males or females ($D_{obs} < D_{alpha}$; Kolmogorov-Smirnov two sample test). Size related bias in the recovery sample was examined by comparing the continuous POH length frequency distributions of tagged and recaptured carcasses (Table 18). Again, no significant differences were observed in males or females ($P > 0.05$).

4. Fish sex: Sex related bias in the application sample was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries (Table 19). No significant differences were noted ($P < 0.05$; chi-square). Bias in the recovery sample was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex ratios in each. No significant differences were noted between the tag and recovery samples ($P < 0.05$; chi-square). Often in high water conditions, fewer tagged males are recovered than females because the larger-bodied (heavier) females tend to remain in the tag area more readily than the lighter-bodied males that are more readily swept downstream. This was not the case, however, and it was simply a matter that fewer male carcasses were available to be tagged.

DISCUSSION

ENUMERATION FENCE

The floating fence design adapts well to the considerable changes in flow that occur during the fall on the Cowichan River. Although it was intended to be self-cleaning, field staff were required to maintain a regular cleaning schedule during times when leafy debris and flooding caused by heavy rains made it difficult for the fence to remain afloat. Due to the considerable number of deciduous trees along the banks of the river, a combination of wind, rain and leaves are the main causes of fence failure. This remains an ongoing problem that is very difficult to overcome (Cousens et. al., 1982; Johnston et. al.,1986).

In most years, the fence is removed due to high water towards the end of the chinook run and mark-recapture population estimates are used to corroborate the fence data and determine the total return. Enumeration data were collected for the time the fence was in full

operation. Although this was the period during which most chinook were presumed to have entered the river, we have no direct count of fish that may have entered before or after the fence was in place and need to rely on swim survey and mark-recapture information. Obviously, the fence count of 3,824 chinook adults and 1,291 jack chinook should be considered an incomplete count of the total run, but the most accurate one available for the time it was in operation. Since the daily count of chinook was minimal when the fence count began, we could assume that the run had just started and few fish had moved upstream past the fence site. Based on information from previous studies (1991-96) for upstream movement after Oct. 30, we estimate that approximately 15% of the run was still to come. If we extrapolate the adult fence on this basis we derive a total count of 4,397 adults.

SWIM SURVEYS

Among the biases typically associated with swim surveys, the extrapolation of actual swim counts to total estimates warrants some consideration (Burns, unpubl). Assumptions concerning the distribution of chinook in the river at the time of the survey are the basis for expanding these counts to estimate total escapement (T. Fields, 230 Underwood St., Duncan, B.C. V9L-3X3, pers comm.). In 1991, it became apparent that during high water flow conditions in early fall, expansions based on the swim survey results overestimated total escapement (Nagtegaal et al. 1994b, 1994c). The results of the 1992 swim surveys support the hypothesis that during low water flow conditions in late fall, expansions based on swim survey results underestimate the number of spawners. Low flow conditions lead to underestimation of spawners because the distribution of fish in the river is affected by flow. Generally, in low water years, not as many fish make it to the traditional spawning areas above Skutz Falls. Expansion of swim surveys conducted in the upper area alone tend to underestimate the number of fish. Conversely, during high water years most of the fish make it above Skutz Falls so the expansion factor tends to overestimate the number of fish.

Flow rate was average during September to November (Fig. 5). Based on the carcass tagging data most chinook spawned in the upper river section in 1999. Since each swim survey count was expanded by the same factor, no consideration was made with regards to the distribution of chinook in the river. The adult escapement estimate for upper river spawners based on the expanded swim count (1,641) was much lower compared to the fence count extrapolation. An insufficient number of swims were made during the season, particularly during the peak and end of the run, to make any appropriate estimates of chinook escapement.

NATIVE FOOD FISHERY

Since we did not have the opportunity to directly assess catch estimation procedures developed by the Cowichan Tribes Aboriginal Fisheries Management unit, no comments could be made regarding the methodologies used. The 1999 estimate of 233 adult chinook was a considerable decrease over last year. The prevailing fishing conditions were considered to be very good during September/October based on information provided by CTAF staff. According to CTAF staff, the spear fishery catch was likely between 600-800 adult chinook. In past, independent observer estimates of adult chinook catch have been 2 to 3.5 times the amount estimated by the CTAF unit. No independent estimates were made in 1999.

BIOLOGICAL DATA

Significant differences were only noted in the adipose mark rate for females between the random broodstock sample recorded by the hatchery staff and the data collected from the spawning grounds by our field staff. The incidence of adipose-clipped female chinook sampled on the spawning ground was 6.3% and in the hatchery chinook broodstock sample was 3.1%. Significant differences were also noted in the size frequency distribution of adult male chinook between hatchery and spawning ground samples ($D_{obs} < D_{alpha}$; Kolmogorov-Smirnov, Zar 1984). This may in a large part be due to the proportionately fewer smaller male carcasses that were recovered in the spawning ground sample. This is likely due to the fact that these lighter carcasses were washed downstream and were not available for biosampling on the spawning ground as readily as the larger and heavier adult carcasses.

Typically, the hatchery collects broodstock from various locations in the river and randomly samples 25% to 50% of males, females and jacks at the hatchery after the fish are spawned. In addition, all other adipose-clipped fish collected for broodstock are selectively sampled for production assessment purposes.

MARK-RECAPTURE

Fall rains that often occur during spawning cause high flows and turbid water. Carcasses are often trapped in deep pools and cannot be seen or easily recovered due to the turbid conditions. Conditions for carcass recovery were generally good in the upper river for the first half of the survey, but were particularly poor in the middle section, with high flows and cloudy water, making it difficult to tag or recover carcasses. On the first sampling trip to the middle section of the river, several hundred live spawners were observed although few carcasses tagged. Subsequent trips to this section were unproductive due to poor tag and recovery conditions. Conditions for tag and

recapture deteriorated rapidly during the last weeks of November. We were able to tag and sample approximately 13% of the total adult chinook escapement.

Stratification by sex was necessary in order to minimize the effects of differential tagging and recovery between sexes. Some potential biases associated with tagging and recovery of carcasses were examined and it was assumed that these could significantly affect the population estimate. For whatever reason, smaller adult carcasses were much less available for tagging and therefore the estimate for males was considered to be low. If we assume that the fence count extrapolation was the preferred method of estimating escapement, then the stratified Petersen estimates based on carcass mark-recapture underestimated escapement by at least 25%. If we assumed the sex ratio to be approximately 50/50 and simply doubled the mark-recapture estimate for females then the result would be approximately 4100 adults. If we then expanded that by 25% to adjust for the numbers that spawned in the middle section of the river, the total estimated adult escapement would be approximately 5100.

SEAL PREDATION

Although seal predation was not directly assessed in this study, it is worthwhile to examine the impact seals have on chinook in Cowichan Bay. In 1988, the number of seals gradually increased from a low of 30 in April to a peak of about 100 in December. According to Olesiuk et al. (1990) harbour seals consume an estimated 9 tonnes of salmon annually in Cowichan Bay. An estimated 23% (Sept.) to 48% (Nov.) of the harbour seals' diet in Cowichan Bay was comprised of salmon (Bigg et al. 1990). Based on these data, consumption of chinook salmon could potentially range from 100 to 500 adults. These data were collected in 1988 when low flows in the Cowichan River persisted until the end of October. Predation likely increases the longer chinook salmon remain in the estuary waiting for high water to allow upstream migration. Predation on chinook in 1999 was estimated to be approximately 300 and somewhat less than the past few years even though low flow conditions occurred in September and October. DFO charter patrol observations indicated that fewer numbers of seals and sea lions were present in Cowichan Bay.

ESCAPEMENT

Escapement (natural spawners and total return) estimates for 1999 were primarily based on fence data since this was the preferred enumeration technique. The number of natural spawners was determined to be the fence count minus broodstock removals above the fence. If we also add an estimate for migration before and after the fence was in place then the total number of spawners is estimated to be approx. 4,500 (Table 20).

Total return of adult chinook to the Cowichan River was determined to be equal to the sum of the fence count and the number of adults removed below the fence by the hatchery for broodstock and in the Native spear fishery. If we also add an estimate for migration before and after the fence was in place then the total return is estimated to be approx. 6,392 (Table 20). If we include a seal predation estimate of 300, then it is probable that the total return of chinook in 1999 was closer to 6,700 adults.

Adult chinook escapements have fluctuated from a low of 1200 in 1986/87 to over 16,000 in 1995, the largest escapement recorded for the past 40 years (Fig. 6). In recent years chinook escapement has increased substantially and came close to or exceeded the escapement goal of 12,500 in 1995 and 1996. This escapement trend may in part be due to substantial increases in hatchery production (Fig. 7) and a reduction in commercial and sport fleet effort. Natural production as well as enhanced contribution to the escapement has increased Fig. 8). However, for the last two years the number of spawners has again dropped well below the escapement goal.

Returns of jack chinook to the Cowichan River were lower than average in 1999. If we use the fence count by year and look at the average jack to adult ratio from 1988-1998 (excluding 1990, 1993-94 when the jack return exceeded the adult count), we find that the jack count was approximately 66% of the adult fence count. This year the ratio was only 33.8% or 1,291 jacks. One explanation for this poor return may be the reduced hatchery production for the 1997 brood year (Fig. 7). This may also indicate poorer returns of 3 and 4 year olds in 2000 and 2001.

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Table 1. Daily counts at the enumeration fence site, Cowichan River, 1999.

Date (DDMM)	Depth (cm.)	Temp. (Deg.C)	Chinook		Coho		Chum	Unknown
			Adult	Jack	Adult	Jack		
2708	0	19	2	1	0	0	0	0
2808	0	19	5	2	0	0	0	0
2908	444	19	0	0	0	0	0	0
3008	447	17	6	9	0	0	0	0
3108	439	17	3	2	0	0	0	0
0109	435	18	7	1	0	0	0	0
0209	445	18	5	5	0	0	0	0
0309	441	17	3	3	0	0	0	0
0409	447	18	2	2	0	0	0	0
0509	427	18	1	0	0	0	0	0
0609	428	17	1	1	0	0	0	0
0709	431	18	3	2	0	0	0	0
0809	426	17	6	3	0	0	0	0
0909	440	18	2	4	0	0	0	0
1009	437	17	5	2	0	0	0	0
1109	440	17	10	12	0	0	0	0
1209	441	17	2	14	0	0	0	0
1309	415	17	0	10	0	0	0	0
1409	423	17	1	3	0	0	0	0
1509	426	17	22	30	0	0	0	0
1609	423	17	34	11	0	0	0	0
1709	400	16	23	5	0	0	0	0
1809	400	16	10	19	0	0	0	0
1909	417	17	8	9	0	0	0	0
2009	411	17	9	7	0	0	0	0
2109	400	16	28	37	0	0	0	0
2209	404	17	13	9	0	0	0	0
2309	408	17	9	19	0	1	0	0
2409	420	16	3	3	0	0	0	0
2509	421	15	51	28	31	11	0	0
2609	400	13	72	34	2	2	0	2
2709	403	14	25	12	11	20	0	1
2809	406	13	39	20	16	19	0	1
2909	406	14	79	61	16	4	0	1
3009	406	14	50	19	23	14	1	1

Table 1 (cont'd)

Date (DDMM)	Depth (cm.)	Temp. (Deg.C)	Chinook		Coho		Chum	Unknown
			Adult	Jack	Adult	Jack		
0110	406	13	91	43	21	22	0	0
0210	403	11	37	20	5	6	0	0
0310	407	13	28	12	7	1	0	0
0410	406	12	48	19	0	2	0	0
0510	408	13	48	34	26	8	0	0
0610	413	13	35	19	11	2	0	0
0710	487	13	133	88	34	28	0	4
0810	576	14	553	120	157	62	0	0
0910	571	14	544	77	61	30	0	11
1010	536	12	55	19	11	6	1	6
1110	550	13	45	11	8	7	1	1
1210	557	12	67	17	7	2	0	0
1310	559	14	287	67	49	50	6	1
1410	558	13	194	50	16	10	0	3
1510	556	13	72	12	14	2	0	0
1610	556	12	29	9	1	5	0	0
1710	548	12	45	5	10	4	1	1
1810	553	12	91	25	18	5	2	0
1910	552	13	41	9	21	3	2	0
2010	551	14	41	19	29	9	1	4
2110	550	12	14	6	6	2	1	0
2210	550	12	19	10	19	3	2	2
2310	554	12	18	20	10	5	1	0
2410	550	12	35	8	12	13	4	0
2510	540	12	45	9	23	4	2	1
2610	538	11	34	8	6	2	3	2
2710	530	11	43	7	19	2	6	2
2810	546	12	416	94	913	145	602	2
2910	572	12	120	39	497	58	912	7
3010	620	12	57	16	243	101	636	6
TOTAL:			3824	1291	2353	670	2184	59

Table 2. Daily counts by time interval at the enumeration fence site, 1999.

Time Period	Chinook			
	Adult	Percent	Jack	Percent
0000 - 0100	198	5.2	107	8.3
0100 - 0200	195	5.1	92	7.1
0200 - 0300	206	5.4	100	7.7
0300 - 0400	198	5.2	115	8.9
0400 - 0500	172	4.5	88	6.8
0500 - 0600	133	3.5	65	5
0600 - 0700	132	3.5	44	3.4
0700 - 0800	300	7.8	67	5.2
0800 - 0900	543	14.2	97	7.5
0900 - 1000	329	8.6	59	4.6
1000 - 1100	183	4.8	25	1.9
1100 - 1200	61	1.6	9	0.7
1200 - 1300	32	0.8	5	0.4
1300 - 1400	31	0.8	1	0.1
1400 - 1500	59	1.5	16	1.2
1500 - 1600	96	2.5	10	0.8
1600 - 1700	136	3.6	22	1.7
1700 - 1800	71	1.9	16	1.2
1800 - 1900	69	1.8	16	1.2
1900 - 2000	58	1.5	16	1.2
2000 - 2100	94	2.5	76	5.9
2100 - 2200	112	2.9	56	4.3
2200 - 2300	195	5.1	75	5.8
2300 - 2400	221	5.8	114	8.8
Total:	3824	100.1	1291	99.7

Table 3. Visual survey data collected for the Cowichan River by Fishery Officers stationed in the Duncan subdistrict.

				Chinook				
				Jacks		Adults		
	Method[1]	Date		Count	Estimate	Count	Estimate	River Segment[2]
1981	S	Sept.	12	175		208	1000	2-4
	S	Oct.	2	103		93	1500	2-4
	S		14	364		1160	4000	2-4
	H		22			2000		1-7
	S		23			3200	5000	2-4
Estimate for Season[3]							5500	
1982	S	Sept.	14	199		131	600	2-4
	S	Oct.	13			153		2-4
	H		19	saw few fish on spawning grounds				1-13
	F	Nov.	8				4000	
Estimate for Season							4500	
1983	S	Sept.	8	38		61	254	2-6
	S		15	62		121	504	2-6
	S		28	190		470	1838	1-2
	S	Oct.	7	207		425	1804	2-6
	S		14	802		997	2836	2-7
	S		25	901		1113	4500	1-6
Estimate for Season							4500	
1984	S	Aug.	28	80		84	400	2-5
	S	Sept.	6	25		72		
	S		13	79		80		3-11
	S		19	35		71		2-6
	S		26	291		434		2-6
	S	Oct.	3	205		283		3-7
	S	"		206		282	2200	8-11
	S		23	525		1300	5000	1-6
	S	Nov.	1	350		1276		1-6
Estimate for Season							5000	
1985	S	Sept.	12	39		46	220	2-6
	S		17	42		10		12-13
	S		18	210		33		2-6
	S		27	245		104	456	2-6
	S	Oct.	3	244		99	360	2-6
	S		10	285		219		2-6
	S		16	293		347		2-6
	S		31	229		934	3500	1-6
Estimate for Season							3500	

Table 3 (cont'd)

				Chinook				
				Jacks		Adults		
	Method[1]	Date		Count	Estimate	Count	Estimate	River Segment[2]
1986	S	Sept.	9	295		85	300	2-6
	S		18	46		29	300	3-6
	S		24	161		56	350	12-13
	S	Oct.	7	1310		223	1000	2-6
	S		29	613		473	1200	1-6
	S	Nov.	6	1178		491	1200	
	H		8			515		1-13
Estimate for Season							1200	
1987	S	Sept.	9	30	300	10	50	3-8
	S		17	111		16	75	2-6
	S		25	112		16	75	3-6, 11-12
	S	Oct.	6	196	800	115	400	2-6
	S		15	196		96		1-6
	H		16		saw very few spawners			1-13
	S		28	417		468		1-6
	S	Nov.	6	329		649		1-6
Estimate for Season							1200	
1988	S	Aug.	25	100		50		2-6
	S	Sept.	1	271		149	700	2-6
	S		23	1464		271	1000	2-6
	S	Oct.	3	821	1600	1094	3500	2-6
	S		14	2008		2076	4000	1-6
Estimate for Season							5500	
1989	S	Sept.	11	151		58	300	2-6
	S		21	95		39	350	3-6
	S	Oct.	5	95		48	700	2-3
	S		18	719		350	1200	2-6
	S	Nov.	1	1537		2267		2-6
Estimate for Season							5000	
1990	S	Aug.	29	254		54	250	2-6
	S	Sept.	14	385		89	1000	3-6
	S		27	3169		477	2200	2-3
	S	Oct.	19	4297		2382	5000	2-6
Estimate for Season							5300	

Table 3 (cont'd)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1991	S	Sept. 19			1882	6000	2-6
	S	Oct. 2			2873	7500	2-6
	S	17			2924	8700	2-6
	S	31			3502[4]	9000	2-6
Estimate for Season						10000	
1992	S	Sept. 16	5		8		2-5
	S	Oct. 2	124		46	200	2-6
	S	15	359		291	700	2-6
	S	15	113		162		2-6
	S	27	514		797	2000	1-6
	S	28	591		767		1-6
	S	Nov. 13	506		467		1-6
	S	13	450		640[5]		1-6
Estimate for Season						7500	
1993	S	Sept. 23	23		14	47	2-6
	S	30	81		62	210	2-6
	S	Oct. 14	207		199	676	2-6
	S	28	127		327	1111	2-6
	S	Nov. 4	480		987	3355	
Estimate for Season[6]						5200	
1994	S	Aug. 24	39		3		2-6
	S	Sept. 14	67		46	156	2-6
	S	28	421		323	1098	2-6
	S	Oct. 13	1253		1146	3896	2-6
	S	26	442		1450	4930	2-6
Estimate for Season[6]						5500	
1995	S	Sept. 28	294		267	1170	2-6
	S	Oct. 25	490		1798	6653	2-6
Estimate for Season[6]						15500	

Table 3 (cont'd)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1996	S	Sept. 13	45		46	147	2-6
	S	26	166		150	510	2-6
	S	Oct. 2	254		534	1815	2-6
	S	9	579		1157	3933	2-6
	S	15	195		707	2403	2-6
	S	22	557		1699	5776	2-6
Estimate for Season[6]						6500	
1997	S	Sept. 23	165		358	1217	2-6
	S	Sept. 25	87		404	1373	2-6
	S	Sept. 30	54		509	1730	2-6
	S	Oct. 16	84		289	980	2-6
	S	Oct. 23	1036		1831	6225	2-6
Estimate for Season[5]						6500	
1998	S	Sept. 25	72		37		2-6
	S	Oct. 13	54		53		2-6
	S	Oct. 20	130		857	2913	2-6
	S	Oct. 26	317		1260	4284	2-6
Estimate for Season						4284	
1999	S	Sept. 10	88		46	221	2-6
	S	Oct. 13	321		342	1641	2-6
Estimate for Season						4500	

[1]S - Swim survey, H - Helicopter survey, F - boat survey
[2]Refer to Fig. 1
[3]Total escapement estimate for adult chinook
[4]516 chinook carcasses were counted in this total
[5]28 chinook carcasses were counted in this total
[6]swim surveys conducted by Cowichan Tribes River Management Unit, total escapement determined by Fishery officers.

Table 4. Native food fish catch estimates for the Cowichan River.

Year[2]	Adult Chinook	Jack Chinook[3]
1981	1500	1500
1982	1000	1000
1983	250	1000
1984	355	700
1985	1000	1000
1986	800	800
1987	800	800
1988	681	450
1989	1055	250
1990	604	214
1991	270	100
1992	260	12
1993	295	22
1994	345	227
1995	533	120
1996	810	150
1997	191	0
1998	1073	0
1999	233	89

[1]Includes chinook caught in the native spear fishery and the in-river gillnet fishery.
[2]Since 1988 data collected by Cowichan Tribes River Management unit. Prior to 1988, data were collected by the local Fishery Officers.
[3] Estimates for jack chinook were not provided in 1997 and 1998.

Table 5. Summary of chinook broodstock collected by the Cowichan hatchery[1], 1999.

Date	Below Fence			At Fence			Above Fence		
	Male	Jack	Female	Male	Jack	Female	Male	Jack	Female
27-Sep	184	0	193						
28-Sep	109	0	125						
29-Sep	10	0	15						
01-Oct	126	1	126						
04-Oct	87	0	71						
05-Oct	36	0	39						
06-Oct	25	0	36						
07-Oct	68	0	56						
08-Oct	19	0	18						
12-Oct	54	0	74						
13-Oct	16	0	16						
14-Oct	7	0	14						
18-Oct	38	0	67						
20-Oct	10	0	9						
25-Oct	2	0	2						
03-Nov									1
04-Nov									2
10-Nov									2
16-Nov									1
17-Nov									1
Total:	791	1	863						5

[1] Based on hatchery field records.

Table 6. Adult and jack chinook used for hatchery broodstock, Cowichan River.

YEAR	Adult chinook	Jack chinook[1]
1981	282	
1982	534	
1983	242	
1984	278	
1985	175	
1986	315	
1987	582	
1988	678	30
1989	535	96
1990	327	1
1991[2]	1755	347
1992	1850	77
1993	2200	228
1994	1357	145
1995	2149	512
1996	1615	258
1997	125	79
1998	1485	201
1999	1659	1

[1]Barry Cordecedo (Salmon Enhancement Program) provided numbers on broodstock collection from 1981-1987. The brood stock numbers provided included jacks, but no reliable records were kept. It was estimated that about 10-15 jacks were collected per year, except in the first few years in the Cowichan River. These estimates were subtacted from the broodstock numbers provided to give an estimate of the number of adult chinook removed from the system.

[2]In addition, 284 males were removed for broodstock but later returned to the river.

Table 7. Summary of chinook broodstock age data[1], 1999.

Age	Males	Females	Total
3	39	67	106
4	16	60	76
5	1	4	5
Total:	56	131	18

[1] Data from random biosample of hatchery chinook broodstock.

Table 8. Length-frequency of chinook carcasses sampled on the spawning grounds, Cowichan river, 1999.

Length (cm)	Males	Jacks	Females
29	0	2	0
30	0	1	0
31	0	0	0
32	0	3	0
33	0	5	0
34	0	2	0
35	0	6	0
36	0	8	0
37	0	11	0
38	0	14	0
39	0	13	0
40	0	13	0
41	0	8	0
42	0	16	0
43	0	9	0
44	0	8	0
45	2	7	0
46	0	3	1
47	1	2	0
48	0	1	0
49	0	0	0
50	3	1	0
51	1	0	1
52	2	0	1
53	1	0	1
54	5	0	2
55	2	1	4
56	2	0	6
57	5	0	11
58	4	0	11
59	9	0	12
60	13	0	13
61	8	0	25
62	12	0	15
63	10	0	18
64	14	0	16
65	11	0	16
66	12	0	13
67	15	0	15
68	10	0	21
69	6	0	14
70	6	0	7
71	9	0	14

Table 8 (cont'd)

Length (cm)	Males	Jacks	Females
72	5	0	11
73	1	0	8
74	0	0	7
75	2	0	6
76	2	0	6
77	0	0	8
78	2	0	2
79	1	0	3
80	1	0	2
81	1	0	0
82	0	0	3
83	0	0	1
84	0	0	1
Total:	178	134	295
Mean Length:	63.9	39.7	65.7
Adipose clips:	4	3	9
Mark rate:	2.2	2.2	3.1

Table 9. Summary of chinook age data collected on the spawning grounds, 1999.

Age	Males	Jacks	Females	Total
2		136		136
3	96		119	215
4	26		88	114
5	4		9	13
6			1	1
Total	126	136	217	479

Table 10. Length-frequency of chinook broodstock[1] collected by the Cowichan River hatchery, 1999.

Length (cm)	Males	Jacks	Females
47	0	1	0
48	0	0	0
49	0	0	0
50	0	0	0
51	1	0	0
52	3	0	1
53	2	0	0
54	7	0	2
55	1	0	3
56	2	0	4
57	2	0	6
58	5	0	7
59	3	0	8
60	3	0	8
61	3	0	13
62	3	0	5
63	3	0	13
64	3	0	9
65	3	0	6
66	4	0	8
67	2	0	9
68	2	0	10
69	3	0	6
70	1	0	10
71	1	0	3
72	3	0	3
73	0	0	5
74	0	0	3
75	3	0	4
76	0	0	3
77	1	0	3
78	0	0	1
79	0	0	1
80	2	0	1
81	0	0	2

[1] Random sample subset of total broodstock collected (does not include selected mark only sample).

Table 10 (cont'd)

Length (cm)	Males	Jacks	Females
82	0	0	1
83	0	0	1
84	0	0	1
Total:	66	1	160
Mean Length:	62.5	47	65.5
Adipose Clips:	2	0	10
Mark Rate:	3%	0	6.3%

Table 11. Coded-wire tag code data from chinook sampled on the spawning grounds, 1999.

Recovery Data				Release Data		
Date (ddmmyy)	Location	Length (POH)	Sex	Brood Year	Tag Code	Location[1]
01-Nov	8	604	F	97	182740	Upper Cowichan (Late)
03-Nov	12	500	M	98	182761	Upper Cowichan (Early)
03-Nov	12	649	M	96	182029	Upper Cowichan (Early)
05-Nov	29	731	F	96	182026	Upper Cowichan (Late)
08-Nov	8	623	F	97	182745	Upper Cowichan (Late)
08-Nov	12	450	J	98	182802	Upper Cowichan (Late)
08-Nov	14	629	F	97	182562	Chemainus
19-Nov	26	682	M	97	182745	Upper Cowichan (Late)
19-Nov	26	605	F		No Pin	
19-Nov	29	745	F	96	182030	Hatchery (Late)
19-Nov	29	589	F	97	182741	Upper Cowichan (Late)
23-Nov	14	429	J	98	182804	Hatchery (Late)
25-Nov	21	582	F	97	182743	Upper Cowichan (Early)

[1] Cowichan Hatchery release strategies for chinook:

Upper Cowichan (Late): raised to pre-smolt size (5-6gm) prior to release approx. 3 km below the weir in May.
Upper Cowichan (Early): raised to fry (3 gm) prior to release approx. 3 km below the weir in early April.
Cowichan Lake Pen: raised to pre-smolt size (5-6gm) prior to release just above the weir in May.
Hatchery (Late): raised to pre-smolt size (5-6gm) prior to release at the hatchery in May.
Seapen: raised to smolt size (6+gm) prior to release from the netpens in Cowichan Bay in early June.

Table 12. Cowichan Hatchery chinook release[1] data, 1979-1999.

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weight (gm)	Release Date ddmmmyy:ddmmmyy	Release site
21846	79	31628	32134	98.4	2.8	:07May80	0118-COWICHAN R
22060	79	32034	32547	98.4	2.8	:07May80	0399-SKUTZ FALLS
22158	80	52519	65000	80.8	2.3	:09Jun81	0118-COWICHAN R
22307	81	30179	30373	99.4	3.1	:12May82	0118-COWICHAN R
22339	82	49135	224944	21.8	2.9	:14May83	0399-SKUTZ FALLS
22831	83	50613	101000	50.1	4.3	:25May84	0355-KOKSILAH R
23803	85	25365	25804	98.3	4.3	23May86:24May86	0118-COWICHAN R
23804	85	25455	25895	98.3	4.3	23May86:24May86	0118-COWICHAN R
23911	85	11980	12187	98.3	4.3	23May86:24May86	0118-COWICHAN R
24334	87	14298	14334	99.7	3.4	:18Apr88	0118-COWICHAN R
24729	87	25360	25424	99.7	3.4	:18Apr88	0118-COWICHAN R
24730	87	25869	25934	99.7	3.4	:18Apr88	0118-COWICHAN R
24731	87	27428	27497	99.7	7.1	18Apr88:18May88	0185-COWICHAN L
24732	87	27271	27339	99.8	7.1	:18May88	0185-COWICHAN L
24733	87	26911	26978	99.8	7.1	:18May88	0185-COWICHAN L
24734	87	23521	23580	99.7	7.1	:18May88	0185-COWICHAN L
24735	87	26719	26786	99.7	3.4	18Apr88:18May88	0118-COWICHAN R
24945	87	26461	123361	21.5	7.5	25May88:26May88	0324-COWICHAN R UP
24946	87	26658	123560	21.6	7.5	25May88:26May88	0324-COWICHAN R UP
24947	87	26761	123663	21.6	7.5	25May88:26May88	0324-COWICHAN R UP
25008	87	26817	123720	21.7	7.5	25May88:26May88	0324-COWICHAN R UP
24860	88	25117	25243	99.5	3.7	:28Apr89	0118-COWICHAN R
25012	88	26595	54768	48.6	6.5	:21May89	0118-COWICHAN R
25013	88	25982	54154	48	6.5	:21May89	0118-COWICHAN R
25015	88	23058	24894	92.6	3.7	:28Apr89	0118-COWICHAN R
25016	88	26821	26821	100	3.7	:28Apr89	0118-COWICHAN R
25017	88	27611	28175	98	3.7	:28Apr89	0118-COWICHAN R
25523	88	27531	56123	49.1	6.5	:21May89	0118-COWICHAN R
25524	88	27205	55378	49.1	6.5	:21May89	0118-COWICHAN R
25749	88	26922	133331	20.2	6.1	:15May89	0185-COWICHAN L
25750	88	27036	133446	20.3	6.1	:15May89	0185-COWICHAN L
25751	88	23106	130107	17.8	6.1	:15May89	0185-COWICHAN L
25752	88	26169	132842	19.7	6.1	:15May89	0185-COWICHAN L
20352	89	28287	28573	99	3.4	12Apr90:12Apr90	0118-COWICHAN R
20522	89	27072	36800	73.6	6.5	22May90:23May90	0118-COWICHAN R
20622	89	27787	37242	74.6	6.5	22May90:23May90	0118-COWICHAN R
20623	89	28164	37619	74.9	6.5	22May90:23May90	0118-COWICHAN R
20624	89	28331	37786	75	6.5	22May90:23May90	0118-COWICHAN R
20938	89	28312	28312	100	3.4	12Apr90:12Apr90	0118-COWICHAN R
20939	89	26218	26218	100	3.4	12Apr90:12Apr90	0118-COWICHAN R
26103	89	27145	27145	100	3.4	12Apr90:12Apr90	0118-COWICHAN R
26255	89	26400	119674	22.1	7.2	:14May90	0185-COWICHAN L
26256	89	25693	119497	21.5	7.2	:14May90	0185-COWICHAN L
26257	89	25790	119325	21.6	7.2	:14May90	0185-COWICHAN L
26258	89	25219	118748	21.2	7.2	:14May90	0185-COWICHAN L
20333	90	25687	94172	27.3	8.4	15May91:15May91	0185-COWICHAN L
20334	90	25898	94384	27.4	8.4	15May91:15May91	0185-COWICHAN L
20335	90	25739	94224	27.3	8.4	15May91:15May91	0185-COWICHAN L
20336	90	27135	27135	100	3.3	17Apr91:17Apr91	0118-COWICHAN R
20337	90	26631	26631	100	3.3	17Apr91:17Apr91	0118-COWICHAN R
20338	90	27046	27046	100	3.3	17Apr91:17Apr91	0118-COWICHAN R
20339	90	26721	34318	77.9	6.4	21May91:22May91	0118-COWICHAN R
20340	90	26993	34592	78	6.4	21May91:22May91	0118-COWICHAN R

Table 12 (cont'd)

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weight (gm)	Release Date ddmmmyy:ddmmmyy	Release site
20341	90	26533	33995	78	6.4	21May91:22May91	0118-COWICHAN R
20342	90	25437	92182	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN R
20343	90	25391	92136	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN R
180513	91	26972	336330	8	5	17May92:17May92	0185-COWICHAN L
180514	91	25964	335584	7.7	5	17May92:17May92	0185-COWICHAN L
180515	91	27694	254287	10.9	4	21Apr92:22Apr92	0335-COWICHAN R LOW
180516	91	27148	254015	10.7	4	21Apr92:22Apr92	0335-COWICHAN R LOW
180517	91	27471	505110	5.4	5.5	19May92:21May92	0324-COWICHAN R UP
180518	91	27277	504916	5.4	5.5	19May92:21May92	0324-COWICHAN R UP
180519	91	27432	160695	17.1	3.8	21Apr92:22Apr92	0335-COWICHAN R LOW
180520	91	27001	160262	16.8	3.8	21Apr92:22Apr92	0335-COWICHAN R LOW
180521	91	26871	27444	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUARY
180522	91	26852	27424	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUARY
180209	92	24770	98974	25	6.3	25May93:25May93	0367-COWICHAN ESTUARY
180210	92	26383	327416	8.1	5.9	17May93:19May93	0324-COWICHAN R UP
180550	92	25311	326344	7.8	5.9	17May93:19May93	0324-COWICHAN R UP
181042	92	53620	412953	13	6.5	25May93:25May93	0118-COWICHAN R
181043	92	54235	901937	6	5.6	10May93:10May93	0185-COWICHAN L
181044	92	55027	907719	6.1	3.6	07Apr93:07Apr93	0324-COWICHAN R UP
21211	93	24875	103900	23.9	6.2	25May94:25May94	3226-COWICHAN BAY
181319	93	49966	1001002	5	6.3	05May94:05May94	0185-COWICHAN L
181320	93	50420	684279	7.4	3.8	18Apr94:18Apr94	0324-COWICHAN R UP
181321	93	50045	652354	7.7	6.1	18May94:18May94	0324-COWICHAN R UP
181322	93	50285	490079	10.3	6.1	24May94:24May94	0118-COWICHAN R
181329	94	25023	103815	24.1	6.1	31May95:31May95	3226-COWICHAN BAY
181436	94	50133	100252	50	5.4	30May95:30May95	0118-COWICHAN R
181437	94	49962	418750	11.9	4	02May95:02May95	0324-COWICHAN R UP
181438	94	49610	939287	5.3	6.3	15May95:17May95	0324-COWICHAN R UP
181439	94	49846	101763	49	6.5	25May95:25May95	0185-COWICHAN L
182023	95	25114	109088	23	6.8	10May96:10May96	3226-COWICHAN BAY
182024	95	25653	297360	8.6	6.6	06May96:06May96	0185-COWICHAN L
182025	95	24488	283856	8.6	6.6	06May96:06May96	0185-COWICHAN L
182026	95	25183	355089	7.1	6.3	07May96:07May96	0324-COWICHAN R UP
182027	95	25218	355583	7.1	6.3	07May96:07May96	0324-COWICHAN R UP
182028	95	25052	344597	7.3	3.5	02Apr96:02Apr96	0324-COWICHAN R UP
182029	95	25129	345657	7.3	3.5	02Apr96:02Apr96	0324-COWICHAN R UP
182030	95	25196	245910	10.2	6.4	09May96:09May96	0118-COWICHAN R
182031	95	25020	244193	10.2	6.4	09May96:09May96	0118-COWICHAN R
182737	96	25235	100196	25.2	6.8	07May97:07May97	3226-COWICHAN BAY
182738	96	25108	318583	7.9	5.4	30Apr97:30Apr97	0185-COWICHAN L
182739	96	25205	319814	7.9	5.4	30Apr97:30Apr97	0185-COWICHAN L
182740	96	25218	448340	5.6	6.3	28Apr97:29Apr97	0324-COWICHAN R UP
182741	96	25649	456002	5.6	6.3	28Apr97:29Apr97	0324-COWICHAN R UP
182742	96	25457	401644	6.3	3.3	01Apr97:01Apr97	0324-COWICHAN R UP
182743	96	25019	394733	6.3	3.3	01Apr97:01Apr97	0324-COWICHAN R UP
182744	96	25154	219780	11.4	5.9	05May97:05May97	0118-COWICHAN R
182745	96	25082	219151	11.4	5.9	05May97:05May97	0118-COWICHAN R
182761	97	25213	25213	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UP
182762	97	25206	25206	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UP
182763	97	25698	25698	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UP
182801	97	24817	28209	88	6.5	13May98:13May98	0324-COWICHAN R UP
182802	97	24890	28282	88	6.5	13May98:13May98	0324-COWICHAN R UP

Table 12 (cont'd)

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weight (gm)	Release Date ddmmmyy:ddmmmyy	Release site
182803	97	24923	28316	88	6.5	13May98:13May98	0324-COWICHAN R UP
182804	97	24971	24971	100	6.5	21May98:21May98	0118-COWICHAN R
182805	97	25026	25026	100	6.5	21May98:21May98	0118-COWICHAN R
183213	97	24915	51754	48.1	6.3	25May98:25May98	3226-COWICHAN BAY
183107	98	25163	224868	11.2	3.1	31Mar99:31Mar99	0324-COWICHAN R UP
183108	98	25201	225208	11.2	3.1	31Mar99:31Mar99	0324-COWICHAN R UP
183109	98	24803	132012	18.8	6.6	10May99:10May99	0324-COWICHAN R UP
183110	98	24927	132676	18.8	6.6	10May99:10May99	0324-COWICHAN R UP
183111	98	25163	75629	33.3	6.3	10May99:10May99	0118-COWICHAN R
183112	98	24875	74763	33.3	6.3	10May99:10May99	0118-COWICHAN R
183726	98	25135	356567	7	5.9	07May99:07May99	0185-COWICHAN L
183727	98	25136	356568	7	5.9	07May99:07May99	0185-COWICHAN L
183728	98	25234	225504	11.2	3.1	31Mar99:31Mar99	0324-COWICHAN R UP
183729	98	25087	224189	11.2	3.1	31Mar99:31Mar99	0324-COWICHAN R UP
183730	98	24867	132354	18.8	6.6	10May99:10May99	0324-COWICHAN R UP
183731	98	24921	132644	18.8	6.6	10May99:10May99	0324-COWICHAN R UP
183732	98	24959	75015	33.3	6.3	10May99:10May99	0118-COWICHAN R
183733	98	25024	75211	33.3	6.3	10May99:10May99	0118-COWICHAN R
183734	98	25127	99928	25.1	5.1	17May99:17May99	3226-COWICHAN BAY

[1] Cowichan Hatchery release strategies for chinook:

Upper Cowichan (Late): raised to pre-smolt size (5-6gm) prior to release approx. 3 km below the weir in May.
Upper Cowichan (Early): raised to fry (3 gm) prior to release approx. 3 km below the weir in early April.
Cowichan Lake Pen: raised to pre-smolt size (5-6gm) prior to release just above the weir in May.
Hatchery (Late): raised to pre-smolt size (5-6gm) prior to release at the hatchery in May.
Seapen: raised to smolt size (6+gm) prior to release from the netpens in Cowichan Bay in early June.

Table 13. Cowichan River daily discharge[1] measured in cu. m/sec for 1999.

(PRELIMINARY) DAILY DISCHARGE IN CUBIC METRES PER SECOND FOR 1999

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	154	174	172	83.9	62.8	73.4	32.3	10.6	7.30	6.38	44.6	95.9	1
2	144	232	165	77.9	59.7	72.2	32.1	10.2	7.11	6.28	43.2	133	2
3	137	209	175	72.2	57.8	70.3	32.7	9.31	6.92	6.65	42.7	124	3
4	131	195	170	67.8	56.3	70.1	32.7	8.79	6.75	6.41	44.5	113	4
5	125	184	151	64.5	54.4	70.4	30.7	8.69	6.73	6.56	43.7	111	5
6	117	206	135	57.5	52.2	69.6	25.4	8.25	6.81	6.68	59.2	144	6
7	111	197	126	52.6	51.6	67.5	25.5	8.11	6.64	9.21	76.2	135	7
8	106	173	118	48.6	48.2	62.9	24.3	7.99	6.42	18.0	86.5	128	8
9	106	153	107	44.4	46.1	56.2	23.9	7.69	6.31	18.2	111	143	9
10	106	139	101	41.4	44.9	50.2	24.6	7.50	6.28	18.0	136	135	10
11	108	131	95.2	40.6	44.6	43.6	24.4	7.40	6.51	17.9	163	127	11
12	105	127	90.9	40.1	44.8	42.3	24.2	7.35	6.23	17.8	181	155	12
13	103	134	102	37.7	42.6	43.9	22.8	7.27	6.20	19.0	157	163	13
14	199	130	112	34.1	38.4	45.7	22.9	7.09	6.51	18.7	151	157	14
15	175	121	105	35.0	35.1	48.8	22.3	7.28	6.35	17.9	139	211	15
16	163	130	98.5	37.7	33.3	51.0	21.2	7.99	6.13	17.3	133	205	16
17	153	143	92.2	42.6	35.6	50.5	21.1	9.83	6.01	16.6	128	188	17
18	192	138	86.8	49.0	42.0	50.5	20.4	9.40	6.22	16.0	117	195	18
19	211	131	84.2	56.0	52.0	49.9	19.0	9.31	6.95	15.6	111	176	19
20	177	124	80.8	66.6	59.0	47.6	18.5	9.23	6.43	15.1	116	161	20
21	164	113	79.7	67.3	62.0	47.1	18.4	8.97	6.09	14.7	113	146	21
22	152	117	81.8	67.4	65.0	46.2	17.6	8.59	6.27	14.3	105	132	22
23	144	125	84.9	68.3	70.0	45.0	16.9	8.44	6.59	14.0	104	122	23
24	135	208	87.1	71.5	75.0	45.0	16.3	8.26	6.38	14.0	115	111	24
25	129	165	87.6	77.3	78.0	44.2	15.5	8.21	6.79	13.5	122	102	25
26	120	143	89.1	78.9	79.5	42.6	14.6	8.36	6.38	13.3	111	94.4	26
27	119	144	86.8	78.9	77.0	41.3	13.7	8.09	6.29	13.0	105	88.4	27
28	122	167	83.6	75.4	75.3	38.9	12.8	7.96	6.39	17.2	102	84.5	28
29	282		92.8	72.0	75.0	32.8	12.2	7.82	6.55	22.0	97.9	78.8	29
30	208		96.6	65.9	74.5	32.3	11.4	7.57	6.48	37.5	96.8	72.8	30
31	168		88.9		74.4		10.6	7.49		50.9		68.7	31
TOTAL	4566	4353	3326.5	1773.1	1767.1	1552.0	661.0	259.04	195.02	498.67	3155.3	4100.5	
MEAN	147	155	107	59.1	57.0	51.7	21.3	8.36	6.50	16.1	105	132	MEAN
MAX	282	232	175	83.9	79.5	73.4	32.7	10.6	7.30	50.9	181	211	MAX
MIN	103	113	79.7	34.1	33.3	32.3	10.6	7.09	6.01	6.28	42.7	68.7	MIN

[1] Water Survey of Canada data recorded at the Island Highway bridge in Duncan.

Table 14. Summary of chinook carcass mark-recapture data from the Cowichan River, 1999.

Area:Upper River

Date	No. Examined			No. Tagged			No. Recaptured		
	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks
0111	14	27	0	14	27	0	2	6	0
0211	11	15	0	11	15	0	3	4	0
0311	23	39	0	23	39	0	3	4	0
0511	8	13	0	8	13	0	1	0	0
0811	9	36	1	9	36	1	5	10	1
0911	5	11	0	5	11	0	0	0	0
1011	6	14	0	6	14	0	2	6	0
1211	1	3	0	1	3	0	0	1	0
1511	10	11	0	10	11	0	4	1	0
1711	6	15	0	6	15	0	3	3	0
1811	21	25	0	21	25	0	5	6	0
1911	20	19	0	20	19	0	0	0	0
2311	25	21	0	25	21	0	9	12	0
2511	18	31	0	18	31	0	3	3	0
2611	17	20	0	17	20	0	1	2	0
2911	5	13	0	5	13	0	1	2	0
3011	25	16	0	25	16	0	7	8	0
0112	7	3	0	7	3	0	3	0	0
0212	3	10	0	3	10	0	1	7	0
0312	4	8	0	4	8	0	0	2	0
0612	1	9	0	1	9	0	0	1	0
0712	1	2	0	1	2	0	0	0	0
Total:	240	361	1	240	361	1	53	78	1

Area:Lower River

Date	No. Examined			No. Tagged			No. Recaptured		
	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks
0511	2	3	0	2	3	0	0	0	0
Total:	2	3	0	2	3	0	0	0	0

Table 15. Petersen chinook escapement estimates by sex, Cowichan River, 1999.

Carcass mark-recapture:

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	1,332	1,011	1,653
Female	2,047	1,638	2,456
Total	3,440	2,908	3,972

[1] Adult males only, jacks not included

Table 16. Incidence of tagged adult chinook carcasses recovered[1] on the spawning grounds by recovery period, in the Cowichan R., 1999.

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Nov. 1-10	46	35.1	277	37.8	16.6
Nov. 11-20	23	17.5	154	21.0	14.9
Nov. 21-30	48	36.6	239	32.6	20.2
Dec. 1-7	14	10.6	62	8.5	22.5
Total:	131	100.0	732	100.0	17.9

[1]includes adult chinook which had lost the tag but had an obvious notch in the operculum or the secondary opercular punch.

Table 17. Proportion of the tag application sample recovered[1] on the spawning grounds, by period, Cowichan R., 1999.

Application period	Tags applied	Tags recovered[2]	Recoveries (%)
Nov. 1-10	231	46	19.9
Nov. 11-20	131	23	17.5
Nov. 21-30	191	48	25.1
Dec. 1-7	48	14	29.1
Total:	601	131	21.8

[1]includes tag recovery for adult chinook only.

[2]includes only those fish recovered with tag intact

Table 18. Summary statistics for Kolmogorov-Smirnov length-frequency comparison for tagged and recaptured chinook carcasses, Cowichan River, 1999.

	CUMULATIVE FREQUENCY						DIFFERENCE		
LENGTH (cm)	MALES TAGGED	MALES RECAPS	FEMALES TAGGED	FEMALES RECAPS	TOTAL TAGGED	TOTAL RECAPS	MALES	FEMALES	TOTAL
29	0	0	0	0	0.003	0	0	0	0.003
30	0	0	0	0	0.005	0	0	0	0.005
31	0	0	0	0	0.005	0	0	0	0.005
32	0	0	0	0	0.01	0	0	0	0.01
33	0	0	0	0	0.018	0	0	0	0.018
34	0	0	0	0	0.021	0	0	0	0.021
35	0	0	0	0	0.031	0	0	0	0.031
36	0	0	0	0	0.044	0	0	0	0.044
37	0	0	0	0	0.063	0	0	0	0.063
38	0	0	0	0	0.086	0	0	0	0.086
39	0	0	0	0	0.107	0	0	0	0.107
40	0	0	0	0	0.129	0	0	0	0.129
41	0	0	0	0	0.142	0	0	0	0.142
42	0	0	0	0	0.168	0	0	0	0.168
43	0	0	0	0	0.183	0	0	0	0.183
44	0	0	0	0	0.196	0	0	0	0.196
45	0.011	0.024	0	0	0.211	0.009	0.013	0	0.202
46	0.011	0.024	0.003	0	0.217	0.009	0.013	0.003	0.209
47	0.017	0.024	0.003	0	0.222	0.009	0.007	0.003	0.214
48	0.017	0.024	0.003	0	0.224	0.009	0.007	0.003	0.215
49	0.017	0.024	0.003	0	0.224	0.009	0.007	0.003	0.215
50	0.034	0.024	0.003	0	0.231	0.009	0.01	0.003	0.222
51	0.039	0.024	0.007	0.014	0.234	0.018	0.016	0.007	0.216
52	0.051	0.071	0.01	0.014	0.239	0.035	0.021	0.004	0.203
53	0.056	0.071	0.014	0.014	0.242	0.035	0.015	0.001	0.207
54	0.084	0.071	0.02	0.028	0.254	0.044	0.013	0.008	0.209
55	0.096	0.071	0.034	0.028	0.265	0.044	0.024	0.006	0.221
56	0.107	0.095	0.054	0.042	0.278	0.062	0.012	0.012	0.216
57	0.135	0.095	0.092	0.056	0.305	0.071	0.04	0.035	0.234
58	0.157	0.095	0.129	0.085	0.329	0.088	0.062	0.044	0.241
59	0.208	0.119	0.169	0.155	0.364	0.142	0.089	0.015	0.222
60	0.281	0.167	0.214	0.197	0.407	0.186	0.114	0.016	0.221
61	0.326	0.19	0.298	0.296	0.461	0.257	0.135	0.003	0.205
62	0.393	0.238	0.349	0.338	0.506	0.301	0.155	0.011	0.205
63	0.449	0.286	0.41	0.366	0.552	0.336	0.164	0.044	0.216
64	0.528	0.381	0.464	0.437	0.601	0.416	0.147	0.028	0.185
65	0.59	0.476	0.519	0.507	0.646	0.496	0.114	0.012	0.15
66	0.657	0.524	0.563	0.549	0.687	0.54	0.133	0.013	0.147
67	0.742	0.667	0.614	0.592	0.736	0.619	0.075	0.022	0.117
68	0.798	0.738	0.685	0.648	0.787	0.681	0.06	0.037	0.106
69	0.831	0.762	0.732	0.676	0.82	0.708	0.07	0.056	0.112
70	0.865	0.81	0.756	0.676	0.842	0.726	0.056	0.08	0.116
71	0.916	0.905	0.803	0.746	0.88	0.805	0.011	0.057	0.074
72	0.944	0.952	0.841	0.789	0.906	0.85	0.009	0.052	0.057
73	0.949	0.952	0.868	0.803	0.921	0.858	0.003	0.065	0.063
74	0.949	0.952	0.892	0.817	0.932	0.867	0.003	0.075	0.065

Table 18 (cont'd)

LENGTH (cm)	CUMULATIVE FREQUENCY MALES TAGGED	MALES RECAPS	FEMALES TAGGED	FEMALES RECAPS	TOTAL TAGGED	TOTAL RECAPS	DIFFERENCE MALES	FEMALES	TOTAL
77	0.972	0.976	0.959	0.915	0.972	0.938	0.004	0.044	0.034
78	0.983	0.976	0.966	0.93	0.979	0.947	0.007	0.037	0.032
79	0.989	1	0.976	0.972	0.985	0.982	0.011	0.004	0.003
80	0.994	1	0.983	0.986	0.99	0.991	0.006	0.003	0.001
81	1	1	0.983	0.986	0.992	0.991	0	0.003	0.001
82	1	1	0.993	0.986	0.997	0.991	0	0.007	0.006
83	1	1	0.997	0.986	0.998	0.991	0	0.011	0.007
84	1	1	1	1	1	1	0	0	0
	$D_{.05,55} = .179$						$D_{obs} =$	0.164	0.081	0.241

Table 19. Sex composition of application and recovery samples of Cowichan River chinook, 1999.

Sex		Application sample			Recovery sample		
		Recovered	Not Recovered	Total	Marked	Unmarked	Total
Male	Percent	40.4	39.8	39.9	40.4	39.9	40.0
	No.	53	187	240	53	240	293
Female	Percent	59.6	60.2	60.1	59.6	60.1	59.9
	No.	78	283	361	78	361	439
Total:	No.	131	470	601	131	601	732

Table 20. Total adult chinook returns to the Cowichan River, 1975-1999.

Year	Natural spawner	Brood stock	Native catch	Total return
1975	6500		900	7400
1976	3460		1000	4460
1977	4150		1000	5150
1978	4370		500	4870
1979	8750	195	500	9445
1980	5950	337	1500	7787
1981	6050	282	1500	7832
1982	5450	534	450	6434
1983	4550	242	250	5642
1984	5050	278	355	5683
1985	3550	175	468	4193
1986	1250	315	481	2046
1987	1200	582	455	2237
1988	4712	678	681	6071
1989	996[1]	535[2]	1055	2586
1990	4164	326	604	5094
1991	4086[3]	1755	270	5065
1992	6676	1850	260	8678
1993	5047	1970	295	7312
1994	4936	1357	345	6638
1995	13452[4]	2149	533	16134[4]
1996	12217[4]	1615	800	14701[4]
1997	7435	125	150	8132
1998	4371	1485	1073	6929
1999	4500	1659	233	6392

[1]For 1989 to the present, the number of natural spawners is calculated as the number of adults recorded at the fence minus the adults removed for broodstock above the fence.
[2]Total broodstock removed.
[3]Includes 2000 adult chinook estimated to have passed by the fence during the period of high water
[4] Includes the fence count and an estimate of the numbers of fish that entered the river prior to and after the fence was in place.

Fig. 1 Cowichan River Survey Areas:

Swim survey locations were:

1 - Bird House pool
2 - Road pool
3 - Train trestle (mile 70.2)
4 - Old pick-up site
5 - Maple tree
6 - Three Firs pool
7 - Skutz Falls
8 - Marie Canyon
9 - Bible Camp
10 - Cowichan side channel
11 - Sandy pool
12 - Sewer
13 - JC pool

Swim survey areas:

Bird House (1) to Three Firs pool (6) represents the Upper survey section.

Marie Canyon (8) to enumeration fence (A) represents the Middle survey section.

A - refers to the adult enumeration fence

Tag recovery locations:

Locations numbered 1 to 45 are in the upper river section, those numbered 46 to 83 are in the middle river section.

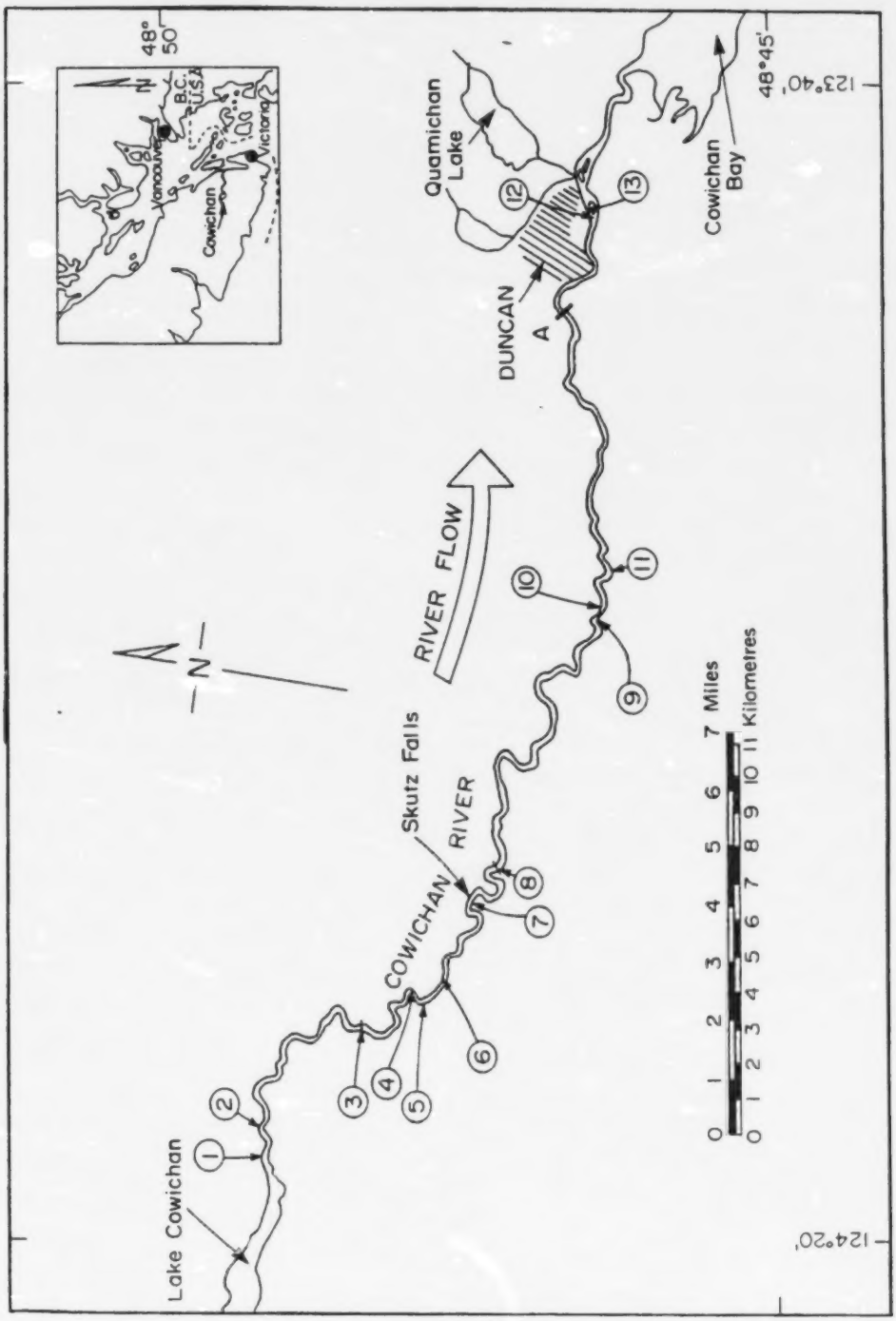

48° 50'
123°40'
48°45'
124°20'
N
B.C.
U.S.A.
Vancouver
Victoria
Cowichan
Lake Cowichan
Quamichan Lake
Cowichan Bay
DUNCAN
A
RIVER FLOW
Skutz Falls
COWICHAN RIVER
1
2
3
4
5
6
7
8
9
10
11
12
13
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres

Fig. 2 River Management Zones for Native Food Fishery

A-Cliffs to Silver bridge

B-Silver bridge to JC's place

C-Quamichan to Black creek

D-Powerline to Elliot's barn

E-Elliot's barn to Brian's pool

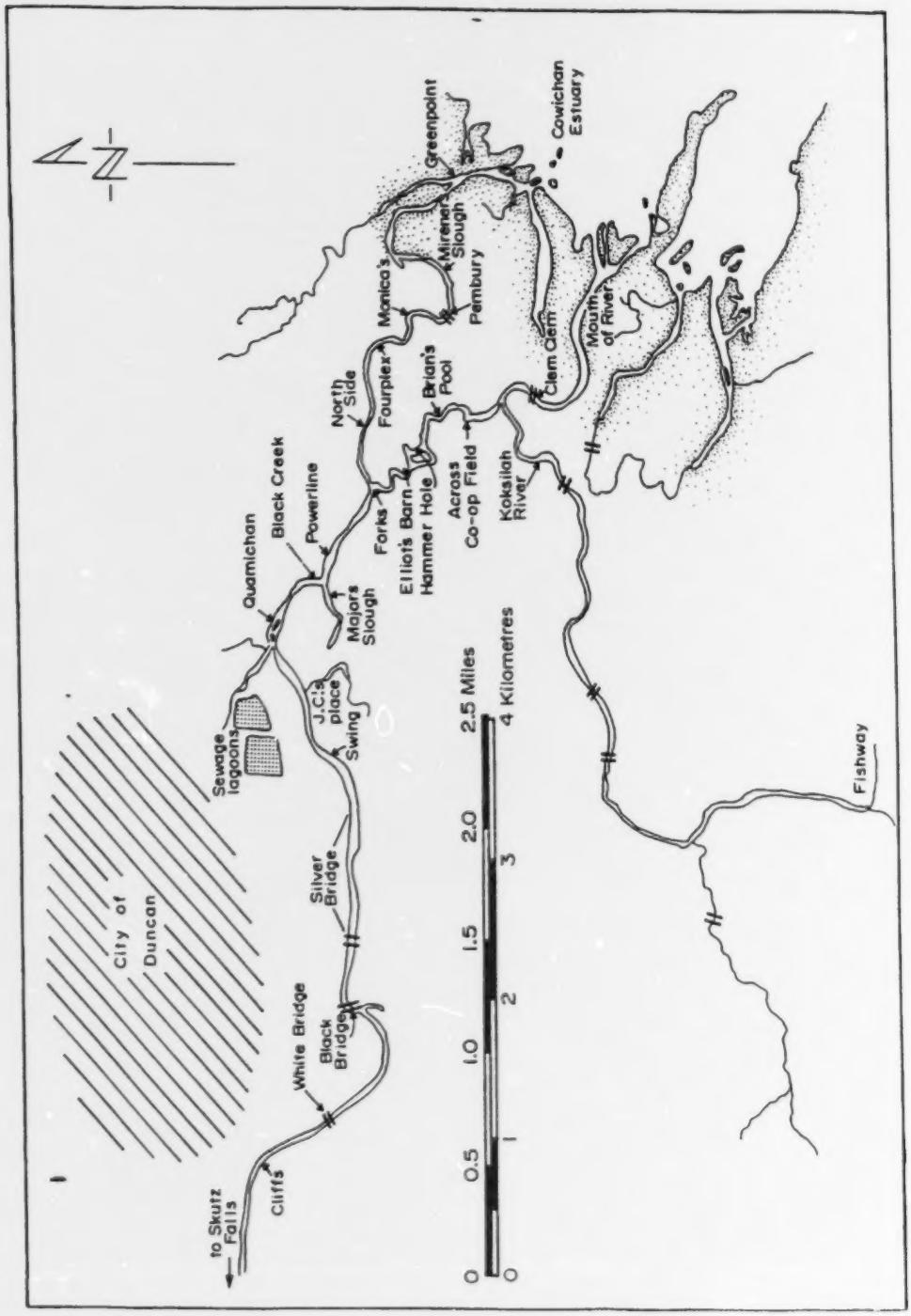
F-Brian's pool to Clem Clem and part of Koksilah

G-Clem Clem to mouth

H-North side to Four plex

I-Four plex to Meriner's slough

J-Meriner's slough to mouth


Greenpoint
Cowichan Estuary
Mirenet Slough
Monica's
Pambury
Clem Clem
Mouth of River
North Side
Fourplex
Brian's Pool
Across Co-op Field
Koksilah River
Forks
Elliot's Barn
Hammer Hole
Powerline
Black Creek
Quamichan
Majors Slough
J.C.'s place
Swing
Sewage lagoons
Silver Bridge
White Bridge
Black Bridge
Cliffs
to Skutz Falls
City of Duncan
Fishway
0
0.5
1.0
1.5
2.0
2.5 Miles
1
2
3
4 Kilometres

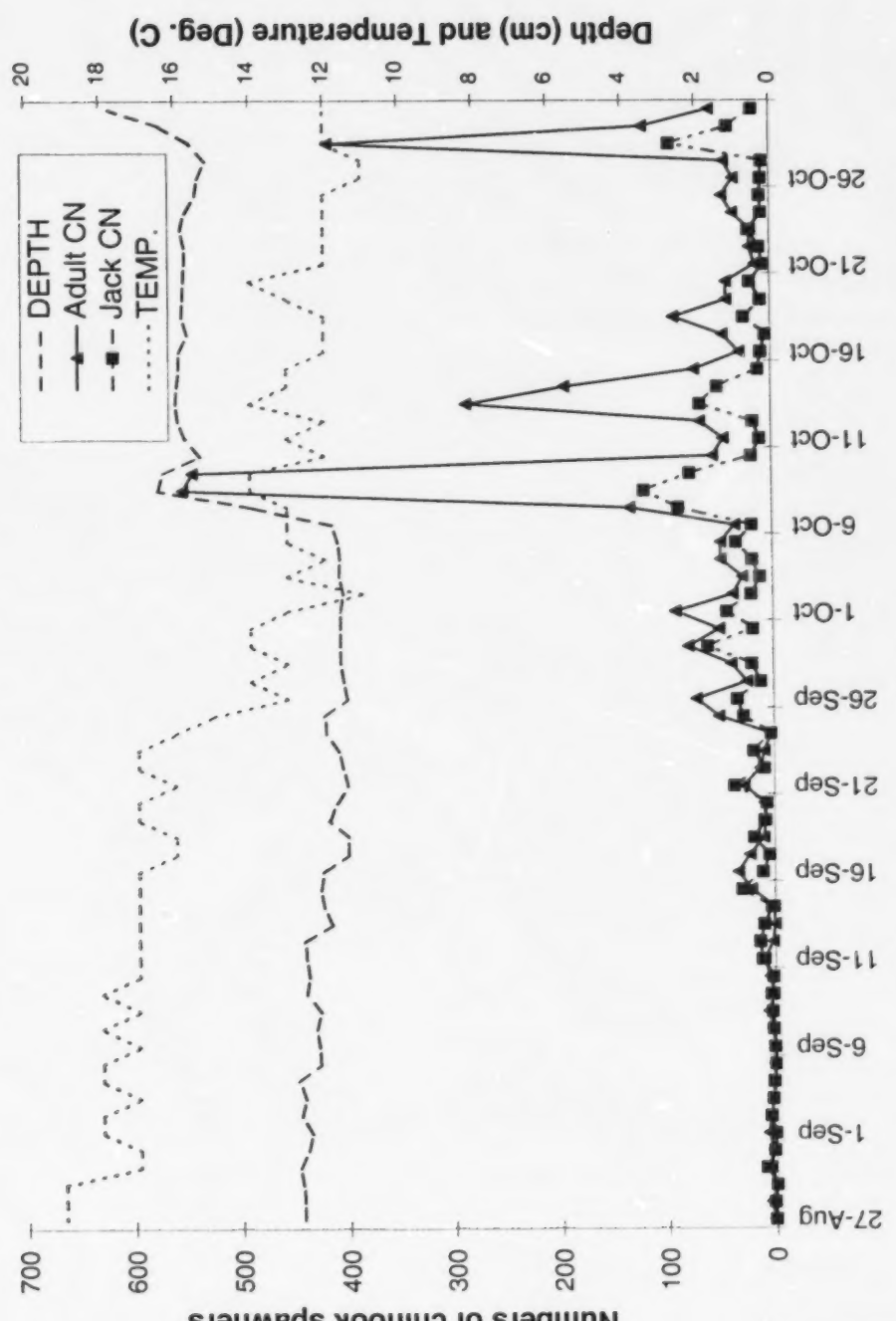


Fig 3. Daily fence count of adult and jack chinook, water depth and temperature, 1999.

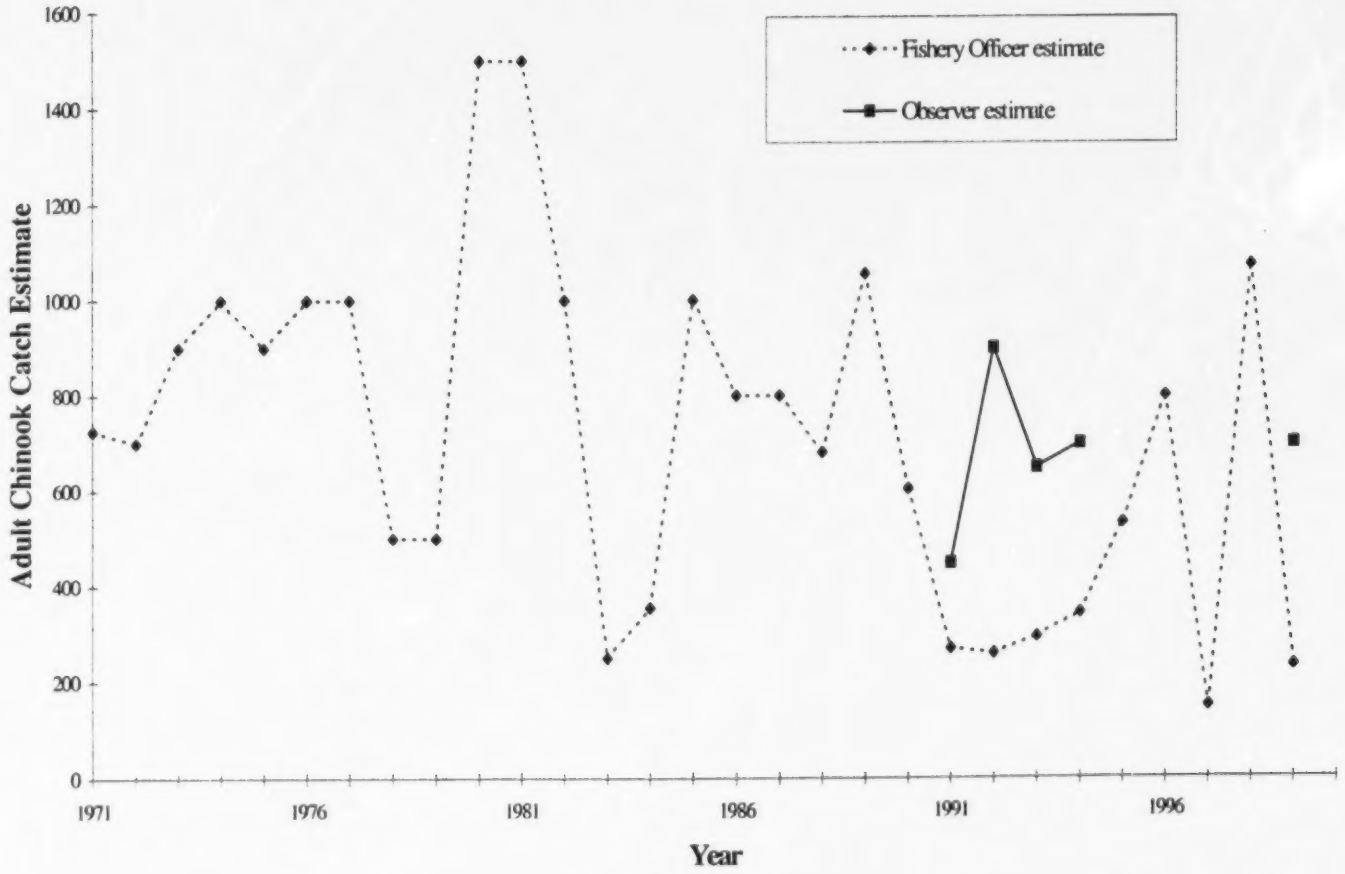


Fig. 4. Adult chinook catch data from First Nations food fishery, Cowichan River, 1971-99.

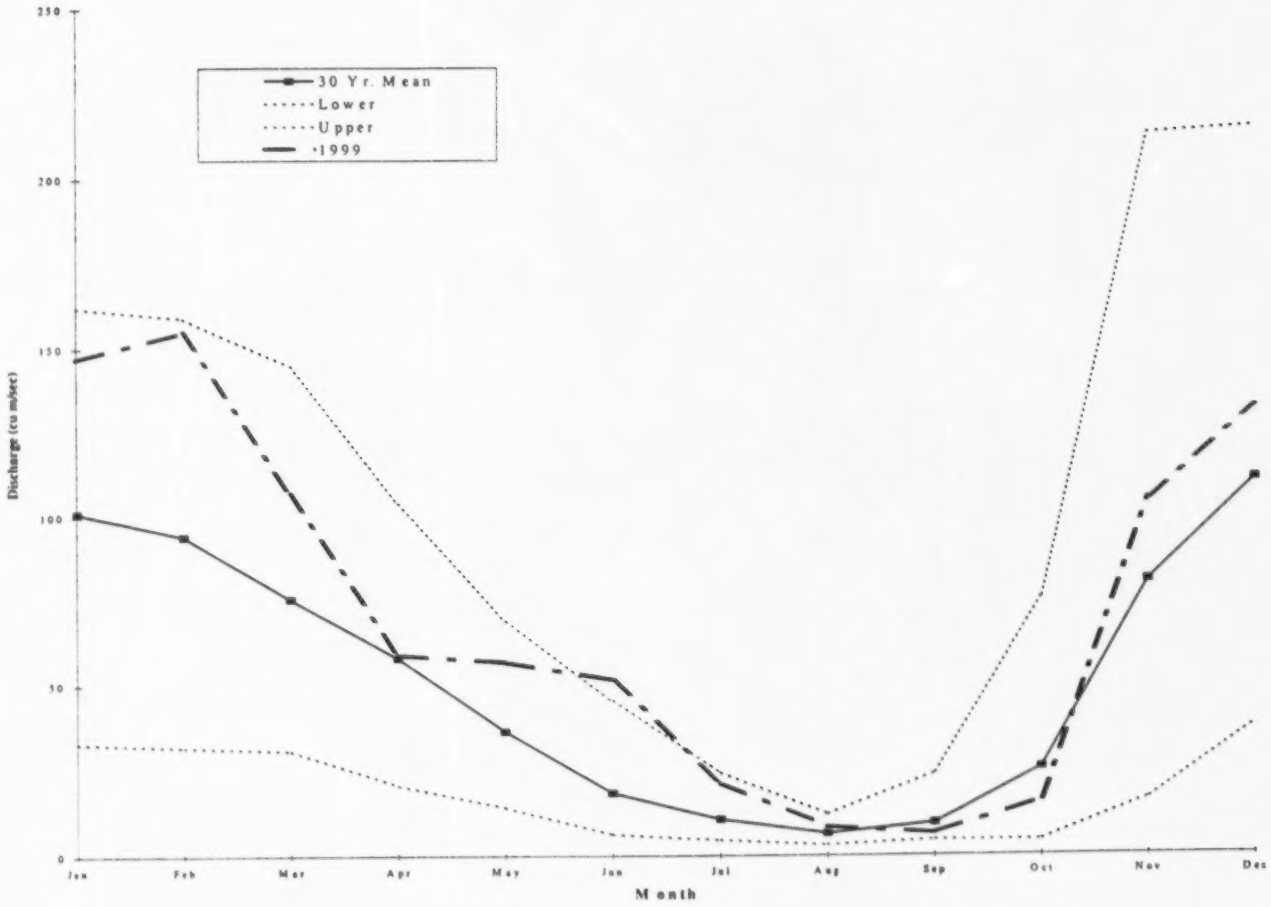


Fig. 5. Cowichan River discharge (cu. m/sec) in 1999 compared with historical trends.

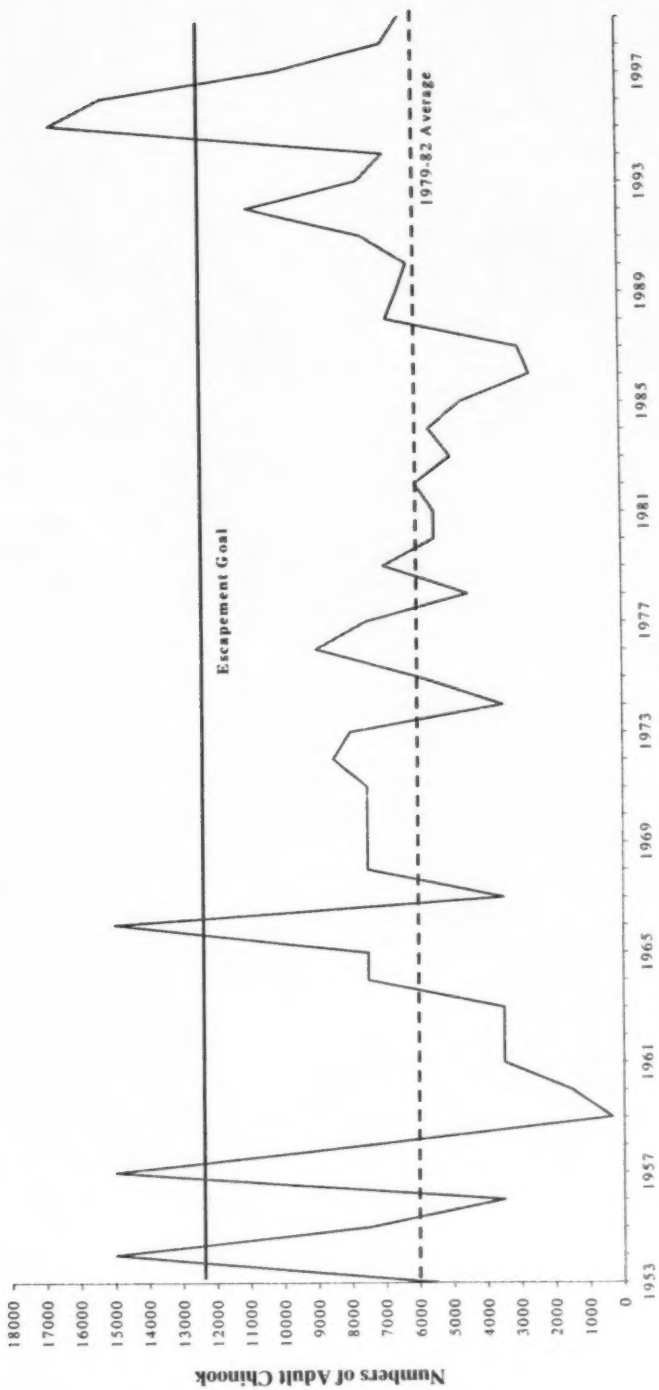


Fig. 6. Adult chinook escapement estimates for the Cowichan River, 1953-99.

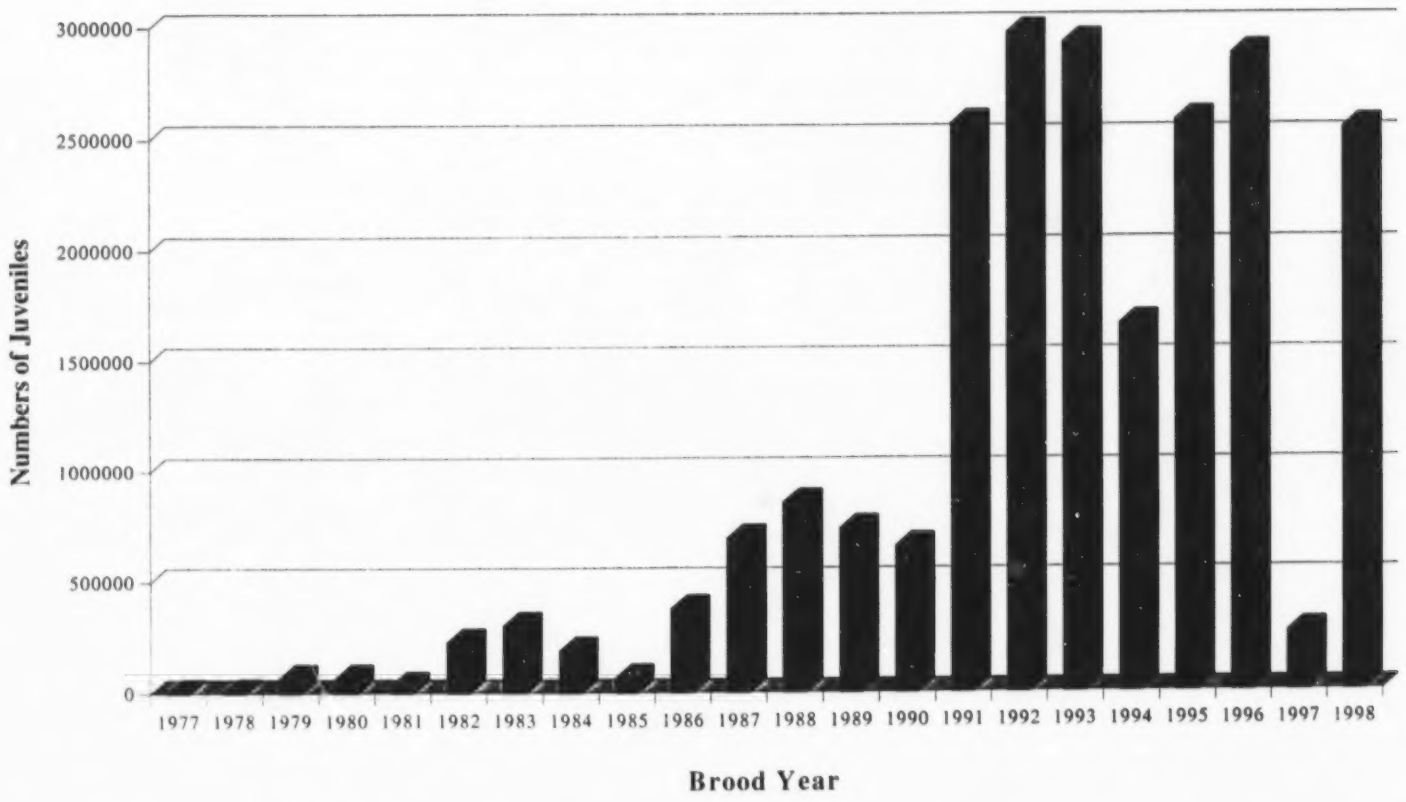


Fig. 7. Hatchery chinook released into the Cowichan River as fry (3 gm) and as pre-smolts (6gm).

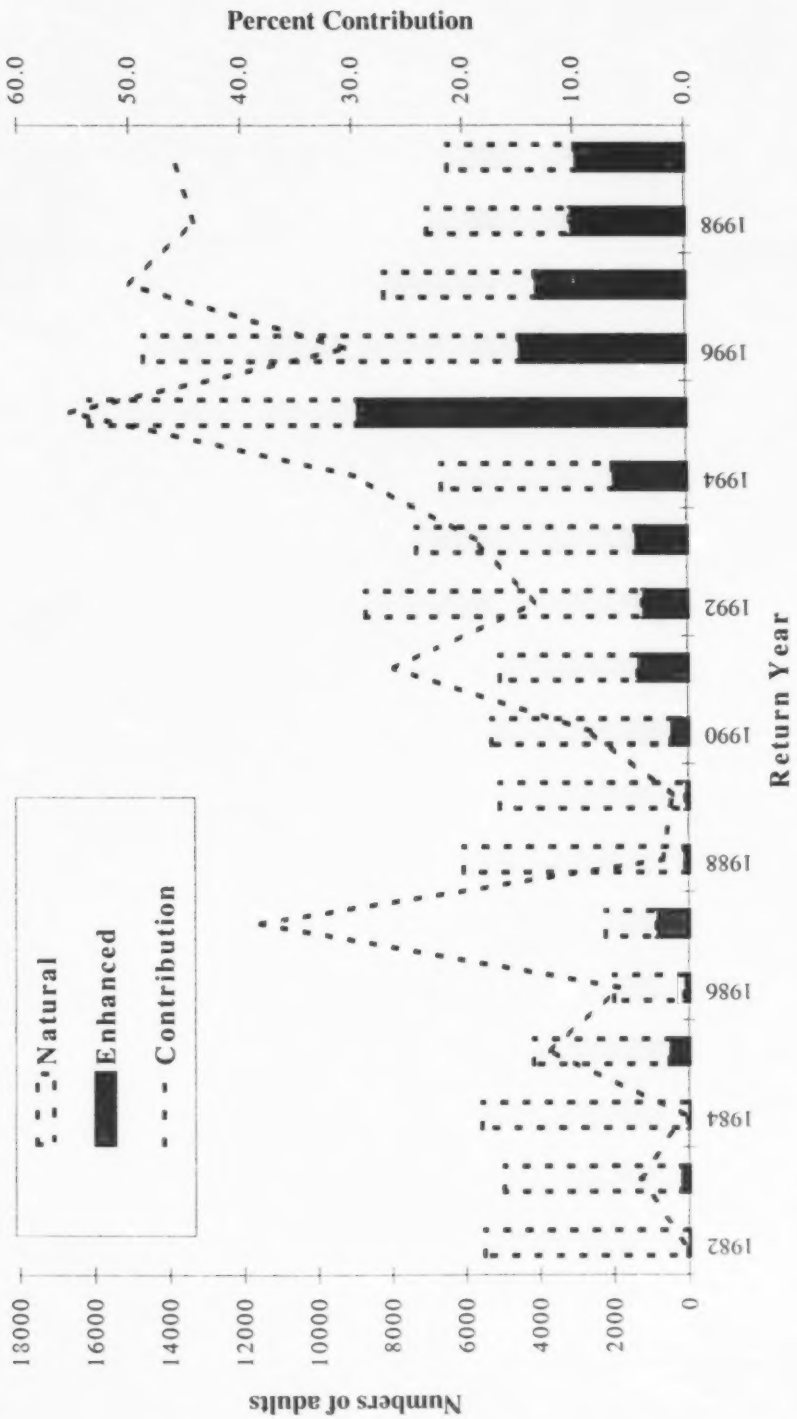


Fig. 8. Natural and enhanced contribution to escapement, Cowichan River, 1982-99.